

Evaluation of Laboratory Facilities Management Strategies for Enhancing Effective Teaching in Technical Colleges in Akwa Ibom State, Nigeria

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Abstract

This study examined laboratory facilities management strategies for enhancing effective teaching in Technical Colleges in Akwa Ibom State, Nigeria. Guided by three research questions and three corresponding hypotheses, the study adopted a descriptive survey research design. The population comprised 179 teachers from six Technical Colleges, from which 130 teachers (82 males and 48 females) were selected using simple random sampling. Data were collected using a 30-item questionnaire, validated by three experts and tested for reliability using Cronbach alpha, yielding an overall reliability coefficient of 0.77. Responses were rated on a five-point scale and data were analyzed using mean, standard deviation and independent t-test at 0.05 significance level. The study found that strategies like safety audits, funding, clear guidelines, staff collaboration, equipment inspection and teacher training are moderately implemented, supporting teaching and learning. From the findings of the study, challenges include inadequate funding, poor infrastructure, unqualified personnel, outdated equipment, unsafe storage, unclear safety procedures and limited practical time. No significant gender differences were observed. The study recommends increased funding, recruitment of qualified staff, professional development, digital inventory and safety systems and sufficient practical time and spare parts to enhance laboratory operations and technical education quality.

Keywords: Laboratory Facilities, Management Strategies, Effective Teaching, Technical Colleges, Akwa Ibom State, Nigeria

Introduction

In Nigeria, Technical and Vocational Education and Training (TVET), particularly in Technical Colleges, emphasizes equipping students not only with general education but also with knowledge of technologies, applied sciences and the practical competencies, attitudes and understanding necessary for careers across various socio-economic sectors (FRN, 2013). Technical education serves a crucial function in industrial advancement, workforce capacity building and ensuring economic resilience, as vocational skills are essential for both employment opportunities and fostering self-dependence. Technical Colleges operate as secondary-level institutions in Nigerian educational framework. Their primary objective is to develop graduates who possess employable skills, relevant knowledge and professional attitudes that enable them to engage in meaningful work or establish self-employment ventures. These fields include carpentry and joinery, furniture and upholstery production, block laying and concreting, plumbing and pipe-fitting, electrical and electronics, automobile craft practice, welding and fabrication, as well as mechanical engineering crafts (Amenger, 2013). According to Akpan, Utuk and Essien (2019), Technical Colleges award certifications such as the National Technical Certificate (NTC), the National Business Certificate (NBC), the Advanced National

Technical Certificate (ANTC) and the Advanced National Business Certificate (ANBC), including the Modular Trade Certificate, all issued by the National Business and Technical Examinations Board (NABTEB).

Alegbemi (2010) emphasized that Technical Colleges in Nigeria are tasked with delivering full-time or part-time training programs in fields like technology, applied sciences and commerce, aligned with the country's industrial, commercial and agricultural needs. Akpan, Utuk and Essien (2019) highlighted that Akwa Ibom State currently has six operational technical colleges dedicated to educating and training its citizens for technological advancement. These include: Government Technical College, Ikot Akata, Mkpato Enin; Government Technical College, Ewet, Uyo; Mainland Technical College, Oron; Union Technical College, Ikpa, Esit Eket; Government Technical College, Ikot Uko, Ika; and Government Technical College, Mbioto, Etinan. These institutions equip young people with essential life skills, preparing them to become competent technicians and artisans capable of contributing to industry and engaging in self-employment. Research underscores the critical function of laboratory facilities in technical and vocational education, highlighting their role as hubs for practical learning, experimentation and skill acquisition (Ogunyemi & Nwosu, 2022). Effective management of these laboratories is fundamental to the success of technical colleges. According to Essien and Udofia (2018), management involves the coordination of activities to achieve desired goals in an efficient and effective manner through the involvement of people. In a similar vein, Brown and Etim (2023) stressed that efficient laboratory management encompasses strategic planning, procurement, optimal utilization, regular maintenance and proper disposal of resources. It also includes the training of instructors, inventory control, enforcement of safety standards and adoption of up-to-date technological tools.

Properly managed and maintained laboratories enhance student engagement in the practical aspects of their studies, promoting creativity, technical problem-solving abilities and hands-on competence. In developed nations, Technical Colleges adopt systematic maintenance routines, employ automated inventory systems and utilize professional lab managers to enrich practical instruction (Smith & Johnson, 2023). Conversely, in many developing nations including Nigeria, the quality of technical education is often compromised due to insufficient laboratory facilities and ineffective management approaches (Adebayo, 2023). Studies reveal that numerous Technical Colleges across Nigeria suffer from poorly maintained labs, obsolete equipment and inadequate upkeep, all of which hinder student learning and reduce employability outcomes (Eze & Okonkwo, 2022). Ineffective laboratory management contributes to student disengagement, diminished interest in practical learning and declining academic performance (Ogunleye, 2023). Many institutions lack comprehensive maintenance frameworks, leading to irregular usage of existing resources. In some cases, old and faulty equipment is left unrepaired or unreplaced, while insufficient training for staff further exacerbates these challenges (Benson & Akpan, 2022).

A major obstacle to effective laboratory management in Nigeria is limited financial resources (Adeyemi & Salami, 2023). The substantial costs involved in acquiring, servicing and upgrading technical apparatus strain the budgets of many institutions, which often lack adequate funding for consistent lab maintenance (Udoh & Uduak, 2020). Additionally, some equipment donated by international bodies remains underutilized due to the shortage of trained personnel to operate them (Uche, 2023). Beyond infrastructure-related concerns, students' attitudes toward the use of laboratory facilities play a crucial role in the effectiveness of hands-on instruction (Olawale, 2023). In some instances, students misuse equipment, leading to frequent malfunctions and the loss of essential tools (Ike, 2023). The absence of well-defined policies regarding the procurement, storage and disposal of laboratory equipment often results in poor management and resource wastage in Technical Colleges across Nigeria (Okafor,

2023). Equally important is the competence of teachers and the quality of administrative supervision in ensuring efficient laboratory operations. Studies indicate that when instructors and laboratory personnel are adequately trained in equipment maintenance, safety protocols and resource management, the quality of practical instruction improves considerably (Garba, 2020). Nevertheless, many Technical Colleges continue to struggle due to limited access to professional development programs for laboratory staff (Akpan & Okorie, 2023).

Despite government interventions through bodies such as the National Board for Technical Education (NBTE) and the Universal Basic Education Commission (UBEC), a significant gap persists between established policies and actual practices in laboratory management in Technical Colleges (Onuoha & Adewumi, 2023). There is a pressing need for a solid policy structure complemented by rigorous monitoring and evaluation mechanisms to enhance laboratory operations and strengthen technical education delivery. The integration of modern technology into laboratory management has been recognized as a global best practice (Brown & Etim, 2023). Advanced solutions such as digital inventory systems, predictive maintenance technologies, automated scheduling tools, smart sensors and real-time monitoring systems have revolutionized laboratory operations in several developed nations (Ogunyemi, 2023; Chukwu, 2023). However, in Nigeria, the use of such technological innovations remains limited, as most Technical Colleges continue to depend on manual documentation and corrective rather than preventive maintenance (Udo & Ekong, 2023). These persistent challenges underscore the need to critically examine existing laboratory management practices and develop a more effective model tailored to support technical education in Akwa Ibom State. Consequently, this study examined the current strategies for managing laboratory facilities in Technical Colleges across Akwa Ibom State.

Statement of the Problem

Technical Colleges in Nigeria are faced with persistent challenges in managing laboratory facilities, resulting in resource shortages, equipment deterioration and poor instructional outcomes (Bello & Adegbite, 2022). Inadequate maintenance, limited funding, obsolete equipment and lack of technical support hinder educators from delivering effective, skill-based instruction (Udoh & Uduak, 2020; Eze & Nwachukwu, 2023). Another challenge according to Aina (2023) is the lack of structured, forward-thinking laboratory management systems, which contributes to frequent equipment breakdowns, poor resource allocation and safety risks. Many Technical Colleges operate outdated laboratories without preventive maintenance and modern inventory tracking mechanisms (Adebayo & Usman, 2023).

These issues restrict students' hands-on experience, reducing employability and impeding national workforce development goals. In contrast, international standards emphasize routine servicing, digital monitoring tools and industry partnerships to enhance laboratory effectiveness (Brown & Etim, 2023; Olawale & Ajibade, 2023). Instructors often lack professional training in lab management, leading to improper equipment handling, inefficient scheduling and disorganized storage (Abdullahi & Okonkwo, 2023). Students also lack training in safety and maintenance, contributing to equipment damage and hazardous learning environments (Eze & Aluko, 2023). Research shows that equipping teachers with lab management skills, maintenance practices and student engagement strategies improves instructional delivery and infrastructure longevity (Adekunle & Usoro, 2023).

In developed countries, technology-driven strategies are adopted for efficient lab operations and safety compliance, whereas developing countries such as Nigerian Technical Colleges rely on outdated manual systems (Smith & Johnson, 2023). The slow adoption of such innovations raises concerns about laboratory sustainability and the quality of technical training. This study therefore, seeks to assess current laboratory management practices, identify major

challenges and recommend innovative, globally-aligned strategies to strengthen technical education sustainability in Akwa Ibom State.

Objectives of the Study

The objective of this study is to evaluate laboratory facilities management strategies for enhancing effective teaching in Technical Colleges in Akwa Ibom State, Nigeria. To achieve the objective, the specific objectives of the study were to:

1. assess the laboratory facilities management strategies implemented in Technical Colleges in Akwa Ibom State.
2. evaluate the effectiveness of the laboratory facilities management strategies implemented in Technical Colleges in Akwa Ibom State towards enhancing teaching and learning.
3. identify the challenges hindering the effective management of laboratory facilities in Technical Colleges in Akwa Ibom State.

Research Questions

To achieve the objectives of this study, the following research questions were formulated to guide the study:

1. What laboratory facilities management strategies are implemented in Technical Colleges in Akwa Ibom State?
2. How effective are the laboratory facilities management strategies in enhancing teaching and learning in Technical Colleges in Akwa Ibom State?
3. What challenges hinder the effective management of laboratory facilities in Technical Colleges in Akwa Ibom State?

Research Hypotheses

HO₁: There is no significant difference in teachers' responses regarding the laboratory facilities management strategies implemented in Technical Colleges in Akwa Ibom State.

HO₂: There is no significant difference in teachers' responses regarding the effectiveness of laboratory facilities management strategies in enhancing teaching and learning in Technical Colleges in Akwa Ibom State.

HO₃: There is no significant difference in teachers' responses regarding the challenges hindering the effective management of laboratory facilities in Technical Colleges in Akwa Ibom State.

Research Methods

Design of the Study

The study employed survey research design. According to Johnny, Effiong and Sheik (2020), survey research design aims to systematically collect and describe data concerning the characteristics, features, or facts about a given population.

Area of the Study

This study was conducted in six Technical Colleges in Akwa Ibom State, one of Nigerian 36 states, created on 23rd September 1987 from the former Cross River State (Akpan & Okoro, 2019). The state covers 8,412 square kilometers (NPC, 2006) and has a population of approximately 3.9 million, comprising 1,983,202 males and 1,918,849 females (National Bureau of Statistics (NBS, 2006). Geographically, it is situated in the coastal southern region of Nigeria, lying between latitudes 4°32'N and 5°33'N and longitudes 7°25'E and 8°25'E

(Essien & Udofia, 2018). It shares boundaries with Cross River State to the east and the Atlantic Ocean to the south (Etuk & Nse, 2021). The predominant ethnic groups in the state are the Ibibio, Annang and Oron (Udoh & Uduak, 2020). Akwa Ibom comprises 31 Local Government Areas (LGAs) and 3 senatorial districts (Akpan & Okoro, 2019). The state economy thrives on civil service, agriculture, fishing and traditional crafts (Udoh & Uduak, 2020). To promote skill development and self-reliance, the state government has upgraded Technical Colleges in each senatorial district to expand access to technical and vocational education (Udoh & Uduak, 2020). These efforts are aligned with national development goals targeting youth employment and industrial productivity. The Ministry of Education and the Board for Technical and Vocational Education have implemented several reforms, including infrastructure development and curriculum enhancement (Akpan & Okoro, 2019).

Population of the Study

The population of the study comprised of 179 teachers in six Technical Colleges in Akwa Ibom State. According to Bornstein, Jager and Putnick (2013), the entirety of all elements under observation, which constitutes all things in any field of investigation, is the study population.

Sample and Sampling Technique

Simple random sampling technique was adopted to select 130 (82 Male and 48 Female) teachers from the six Technical Colleges in Akwa Ibom State. A sample refers to a section or subset of the study population chosen for investigation through a sampling process (Taherdoost, 2016). In the same vein, Nardi (2018), stated that sampling technique is essential for estimating the required data volume and comprehending the data gathering process in a population to fulfill the study objectives.

Instrument for Data Collection

The data for the study were gathered from both primary and secondary sources. The primary data were collected using questionnaire while the secondary data were gathered from text books, journals and online materials (Google Scholar, Research Gates, Scopus, among others). The researchers developed a 30-item structured questionnaire titled: Laboratory Facilities Management Strategies for Enhancing Effective Teaching in Nigerian Technical Colleges Questionnaire (LAFMSEETNTCQ). A questionnaire according to Nardi (2018) is the most common instrument or technique used to acquire descriptive data from a sample group in survey research because the respondents have the advantage of supplying data and information from the source. The instrument was divided into five sections; A - D. Section A comprised of items eliciting information on staff demographic data, while sections B - D comprised of items on implementation strategies, effectiveness and challenges of laboratory facilities management strategies in enhancing teaching and learning in Technical Colleges in Akwa Ibom State. The instrument was designed with a 5-point rating scale of Strongly Agreed (SA=4.50-5.00), Moderately Agreed (MA=3.50-4.49), Lowly Agreed (LA=2.50-3.49), Undecided (U=1.50-2.49), Strongly Disagreed (SD =1.00-1.49) used to answer research questions.

Validation of the Instrument

The research instruments were given to three research experts for face validation. Two of the experts from the Department of Measurement and Evaluation and one expert in Department of Technical Education, University of Uyo, Akwa Ibom State. These experts were requested to read through the instrument item by item, make corrections, indicate the suitability of the items, language used and the arrangement of the items in logical and chronological

sequence. Their comments, suggestions, corrections and other inputs were included in the instrument and used for the final copy.

Reliability of the Instrument

To ensure the reliability of the instrument, it was trial-tested on 25 teachers who were not part of the study. Cronbach alpha statistics was used to determine the reliability coefficient of the instrument which yielded overall reliability index .77 comprising of .78, .71, .83 and .75 for section B, C, D and E respectively indicating that the instrument was reliable. Cronbach's alpha test according to Taber (2017) is the most commonly used method to assess the accuracy of scales with value between 0 and 1. Cronbach's alpha coefficient should be between 0.7 and above to demonstrate the scale's reliability (Cronbach, 1951).

Method of Data Collection

The administration of the instrument was done with the assistance of three research assistants who were briefed before administration of the instrument to the students. A letter of information and consent were part of the information provided to the students. Since the questionnaire was distributed face to face, the participants read the letter of information and consent form and confirmed their voluntary participation. The One hundred (100) copies of the questionnaire administered were all retrieved, indicating a 100% instrument retrieval.

Data Analysis

Mean scores and Standard Deviation were used in answering the research questions while t-test statistics was used to test the three null hypotheses at .05 level of significance. The data collected were analyzed using Statistical Package for the Social Sciences 26 (SPSS).

Results and Analysis of Results

The data analysis and interpretation of results are presented according to the research questions and hypothesis formulated for the study. Data of each research question are presented on a separate table to aid comprehension of the analysis and interpretation of results.

Research Question 1: What laboratory facilities management strategies are implemented in Technical Colleges in Akwa Ibom State?

Table 2: Mean rating of male and female teachers on laboratory facilities management strategies implemented in Technical Colleges in Akwa Ibom State.

S/N	SECTION B: Laboratory Facilities Management Strategies	Male (N=82)		Female (N=48)	
		$\bar{x}$	SD	$\bar{x}$	SD
1.	Regular safety audits are conducted to maintain a safe lab environment.	3.68	0.82	3.54	0.58
2.	Adequate funding is provided for lab equipment maintenance and development.	3.84	0.75	3.63	0.51
3.	Clear guidelines exist for using and maintaining lab equipment.	3.67	0.71	3.65	0.73
4.	Teachers and management collaborate to improve lab facilities.	3.61	0.56	3.53	0.51
5.	Laboratory spaces are well-organized for efficient use during practicals.	3.58	0.69	3.54	0.57
6.	Laboratory equipment is routinely inspected for functionality.	3.66	0.40	3.57	0.68
7.	Facilities are regularly upgraded to align with modern technical education needs.	3.54	0.73	3.69	0.52
8.	Teachers receive training on proper lab equipment use and care.	3.57	0.67	3.56	0.56
9.	Laboratory resources are managed to minimize waste and ensure optimal use.	3.59	0.68	3.63	0.49
10.	Adequate storage systems are provided to prevent damage or loss of laboratory materials	3.68	0.44	3.57	0.63
Grand Mean and Standard Deviation		3.64	0.65	3.59	0.58

***NOTE:** SA (4.50-5.00), MA (3.50-4.49), LA (2.50-3.49), U (1.50-2.49), SD (1.00-1.49)

The data in Table 2 indicated that both male and female teachers perceived the implementation of laboratory facilities management strategies in Technical Colleges in Akwa Ibom State as moderately effective, with grand mean scores of 3.64 (SD = 0.65) for males and 3.59 (SD = 0.58) for females, placing them in the “Moderately Agreed” range (3.50-4.49). Strategies such as provision of adequate funding for equipment maintenance (3.84 for males, 3.63 for females), conducting regular safety audits (3.68 for males, 3.54 for females), collaboration between teachers and management (3.61 for males, 3.53 for females), routine equipment inspection (3.66 for males, 3.57 for females) and provision of adequate storage systems (3.68 for males, 3.57 for females) were moderately implemented, reflecting consistent efforts to maintain functional and safe laboratory environments. Other areas, including clear usage guidelines, organization of lab spaces, regular upgrading of facilities, teacher training and resource management to minimize waste, also exhibited moderate implementation, with mean ratings ranging from 3.54 to 3.69. The relatively low standard deviations suggested that teachers’ perceptions were fairly consistent, indicating a shared understanding of the level of strategy implementation.

Research Question 2: How effective are the laboratory facilities management strategies in enhancing teaching and learning in Technical Colleges in Akwa Ibom State?

Table 3: Mean rating of male and female teachers on effectiveness of laboratory facilities management strategies in enhancing teaching and learning in Technical Colleges in Akwa Ibom State.

S/N	SECTION C: Effectiveness of Laboratory Facilities Management Strategies	Male (N=82)		Female (N=48)	
		$\bar{x}$	SD	$\bar{x}$	SD
1.	Timely maintenance of laboratory equipment prevents interruptions during lessons	3.61	0.75	3.53	0.53
2.	The organization and layout of laboratories support effective practical teaching and learning	3.63	0.53	3.59	0.45
3.	Regular inspections ensure that laboratory equipment remains in good working condition.	3.57	0.50	3.64	0.58
4.	Safety measures in the laboratory reduce accidents and improve the learning environment	3.65	0.69	3.51	0.54
5.	Teacher training in laboratory equipment management improves teaching effectiveness.	3.73	0.59	3.65	0.45
6.	Teachers and students can easily access well-maintained laboratory equipment.	3.57	0.78	3.52	0.55
7.	Funding for laboratory facilities meets the requirements of technical programs.	3.51	0.56	3.54	0.33
8.	Laboratory equipment is upgraded regularly to reflect current technological standards.	3.78	0.51	3.67	0.54
9.	Laboratories are equipped with tools and materials aligned with the curriculum.	3.54	0.44	3.53	0.48
10.	Current laboratory management strategies improve student engagement during practical sessions.	3.66	0.57	3.72	0.67
Grand Mean and Standard Deviation		3.63	0.59	3.59	0.51

***NOTE:** SA (4.50-5.00), MA (3.50-4.49), LA (2.50-3.49), U (1.50-2.49), SD (1.00-1.49)

The data in Table 3 showed that laboratory facilities management strategies in Technical Colleges in Akwa Ibom State were moderately effective in enhancing teaching and learning, with grand mean scores of 3.63 (SD = 0.59) for male teachers and 3.59 (SD = 0.51) for female teachers, falling in the “Moderately Agreed” range (3.50-4.49). Strategies such as regular upgrading of laboratory equipment to current technological standards (3.78 for males, 3.67 for females), teacher training in laboratory equipment management (3.73 for males, 3.65 for females) and implementation of safety measures to reduce accidents (3.65 for males, 3.51

for females) were particularly recognized for their positive impact on teaching effectiveness and the learning environment. Other factors, including timely maintenance of equipment, organized laboratory layouts, accessibility of well-maintained resources, adequate funding, curriculum-aligned tools and enhanced student engagement during practical sessions, also showed moderate effectiveness, with mean ratings ranging from 3.51 to 3.72. The relatively low standard deviations indicated consistency in teachers' perceptions regarding the effectiveness of these strategies.

Research Question 3: What challenges hinder the effective management of laboratory facilities in Technical Colleges in Akwa Ibom State?

Table 4: Mean rating of male and female teachers on the challenges hindering the effective management of laboratory facilities in Technical Colleges in Akwa Ibom State.

S/N	SECTION D: Challenges Hindering Effective Management of Laboratory Facilities	Male (N=82)		Female (N=48)	
		$\bar{x}$	SD	$\bar{x}$	SD
1.	Lack of qualified personnel limits effective management of laboratory resources.	4.83	1.36	4.69	0.94
2.	Inadequate infrastructure fails to meet the growing demands of laboratory activities.	4.59	0.69	4.51	0.77
3.	Poor condition of laboratory equipment disrupts teaching and learning.	4.55	1.24	4.53	0.68
4.	Limited access to modern tools and equipment hinders effective technical instruction.	4.61	1.38	4.58	0.65
5.	Insufficient funding delays maintenance, repairs and upgrades of laboratory facilities.	4.89	0.99	4.62	0.70
6.	Unavailable spare parts slow down the repair and functionality of laboratory equipment.	4.64	1.26	4.52	0.82
7.	Poor storage and organization result in equipment damage and inefficiency.	4.78	0.93	4.57	0.67
8.	Absence of clear laboratory safety procedures increases the risk of accidents.	4.93	0.81	4.50	0.92
9.	Bureaucratic delays affect the timely procurement of laboratory equipment and materials.	4.71	1.47	4.66	0.89
10.	Limited time allocated for practical sessions restricts effective use of laboratory resources.	4.96	0.99	4.59	0.83
Grand Mean and Standard Deviation		4.75	1.11	4.58	0.79

***NOTE:** SA (4.50-5.00), MA (3.50-4.49), LA (2.50-3.49), U (1.50-2.49), SD (1.00-1.49)

The data in Table 4 revealed significant challenges hindering the effective management of laboratory facilities in Technical Colleges in Akwa Ibom State, with grand mean scores of 4.75 (SD = 1.11) for male teachers and 4.58 (SD = 0.79) for female teachers, placing the responses in the "Strongly Agreed" range (4.50-5.00). Key challenges identified included insufficient funding for maintenance and upgrades (4.89 for males, 4.62 for females), limited time allocated for practical sessions (4.96 for males, 4.59 for females), absence of clear laboratory safety procedures (4.93 for males, 4.50 for females), lack of qualified personnel (4.83 for males, 4.69 for females), inadequate infrastructure (4.59 for males, 4.51 for females) and poor storage and organization of resources (4.78 for males, 4.57 for females). Additional issues, such as poor equipment condition, limited access to modern tools, unavailable spare parts and bureaucratic delays in procurement, further exacerbated inefficiencies in laboratory management. The relatively consistent standard deviations suggested that teachers largely shared these perceptions.

Hypotheses 1: There is no significant difference in teachers' responses regarding the laboratory facilities management strategies implemented in Technical Colleges in Akwa Ibom State.

Table 5: *t-test analysis on teachers' responses regarding the laboratory facilities management strategies implemented in Technical Colleges in Akwa Ibom State.*

Group	N	Mean	SD	t-calculated	df	p-value	Decision
Male	82	3.64	0.65	0.84	128	0.40	Not Significant
Female	48	3.59	0.58				

The t-test analysis indicated that the calculated t-value ($t = 0.84$) was less than the critical t-value at 0.05 significance level and the p-value (0.40) was greater than 0.05. This implies that there was no statistically significant difference between the mean responses of male and female teachers regarding the laboratory facilities management strategies implemented in Technical Colleges in Akwa Ibom State. Therefore, Hypothesis 1 was not rejected, suggesting that teachers, irrespective of gender, had similar perceptions on the implementation of laboratory facilities management strategies.

Hypotheses 2: There is no significant difference in teachers' responses regarding the effectiveness of laboratory facilities management strategies in enhancing teaching and learning in Technical Colleges in Akwa Ibom State.

Table 6: *t-test analysis on teachers' responses regarding the effectiveness of laboratory facilities management strategies in enhancing teaching and learning in Technical Colleges in Akwa Ibom State.*

Group	N	Mean	SD	t-calculated	df	p-value	Decision
Male	82	3.63	0.59	0.78	128	0.44	Not Significant
Female	48	3.59	0.51				

The t-test analysis indicated that the calculated t-value ($t = 0.78$) was less than the critical t-value at 0.05 significance level and the p-value (0.44) was greater than 0.05. This implies that there was no statistically significant difference between the mean responses of male and female teachers on the effectiveness of laboratory facilities management strategies. Therefore, Hypothesis 2 was not rejected, suggesting that both genders perceived the effectiveness of the strategies similarly.

Hypotheses 3: There is no significant difference in teachers' responses regarding the challenges hindering the effective management of laboratory facilities in Technical Colleges in Akwa Ibom State.

Table 7: *t-test analysis on teachers' responses regarding the challenges hindering the effective management of laboratory facilities in Technical Colleges in Akwa Ibom State.*

Group	N	Mean	SD	t-calculated	df	p-value	Decision
Male	82	4.75	1.11	1.42	128	0.16	Not Significant
Female	48	4.58	0.79				

The t-test analysis showed that the calculated t-value ($t = 1.42$) was less than the critical t-value at 0.05 significance level and the p-value (0.16) was greater than 0.05. This indicates that there was no statistically significant difference between male and female teachers' responses regarding the challenges hindering effective laboratory management. Therefore, Hypothesis 3 was not rejected, implying that teachers, regardless of gender, largely agreed on the key challenges affecting laboratory management.

Discussion of Findings

The findings for Research Question 1 revealed that laboratory facilities management strategies in Technical Colleges in Akwa Ibom State were moderately implemented, with teachers perceiving strategies such as regular safety audits, adequate funding, collaboration between staff and management, routine equipment inspection and proper storage as contributing to functional and safe laboratory environments. Hypothesis 1, which posited no significant difference in teachers' responses regarding the implementation of these strategies, was not rejected, indicating uniform perceptions across genders. These results showed that while strategies existed, their implementation was inconsistent, leaving room for improvement to optimize teaching and learning outcomes. The moderate level of implementation aligned with previous studies highlighting the critical role of strategic planning, resource allocation and staff training in enhancing laboratory effectiveness (Brown & Etim, 2023; Essien & Udofia, 2018). Conversely, the findings contrasted with research indicating that insufficient funding, outdated equipment and lack of structured management frameworks often impeded effective laboratory operations in Nigerian Technical Colleges (Adebayo & Usman, 2023; Udoh & Uduak, 2020). The study underscored the need for systematic approaches, including professional development, digital inventory systems and regular monitoring, to strengthen the effectiveness of laboratory management strategies.

The findings for Research Question 2 indicated that the laboratory facilities management strategies employed in Technical Colleges in Akwa Ibom State were moderately effective in enhancing teaching and learning, with teachers reporting that measures such as timely maintenance, organized laboratory layouts, safety protocols, teacher training and regular upgrading of equipment positively influenced practical instruction and student engagement. Hypothesis 2, which stated that there would be no significant difference in teachers' perceptions of the effectiveness of these strategies, was not rejected, demonstrating consistent perceptions across male and female teachers. These results revealed that while current strategies contributed to improved instructional delivery and learner outcomes, they were not yet optimized for maximum effectiveness. The findings corroborated earlier studies emphasizing that proper planning, staff competence and adherence to safety and operational protocols enhanced the quality of technical education (Essien & Udofia, 2018; Brown & Etim, 2023). Conversely, the results contrasted with reports highlighting that inadequate training, poor infrastructure and limited access to modern equipment in Nigerian Technical Colleges undermined the effectiveness of laboratory operations and practical learning (Adebayo, 2023; Eze & Okonkwo, 2022). The study underscored the importance of integrating structured professional development, digital monitoring systems and preventive maintenance frameworks to elevate the effectiveness of laboratory management, ensuring that practical instruction fully supported skill acquisition and student learning outcomes.

The findings for Research Question 3 revealed that significant challenges hindered the effective management of laboratory facilities in Technical Colleges in Akwa Ibom State, with teachers identifying issues such as insufficient funding, inadequate infrastructure, lack of qualified personnel, poor equipment condition, limited access to modern tools, unclear safety procedures and restricted practical session time. Hypothesis 3, which posited no significant difference in teachers' perceptions of these challenges, was not rejected, indicating a consensus across genders regarding the systemic barriers affecting laboratory operations. These results noted that despite the presence of management strategies, structural and operational constraints substantially limited their effectiveness in supporting teaching and learning. The findings aligned with prior research emphasizing that inadequate financial resources, obsolete equipment and insufficiently trained staff compromised the quality and sustainability of laboratory-based technical education in Nigeria (Adebayo & Usman, 2023; Udoh & Uduak,

2020; Eze & Aluko, 2023). Similarly, studies indicated that the absence of well-defined safety protocols and proper storage systems exacerbated inefficiencies and increased the risk of accidents, undermining practical skill acquisition (Benson & Akpan, 2022; Okafor, 2023). Conversely, research from developed contexts highlighted that systematic maintenance, digital inventory systems and professional development for instructors significantly mitigated these challenges and enhanced learning outcomes (Brown & Etim, 2023; Smith & Johnson, 2023).

Conclusion

This study established that laboratory facilities management strategies in Technical Colleges in Akwa Ibom State are moderately implemented and moderately effective in enhancing teaching and learning, yet significant challenges including inadequate funding, insufficient infrastructure, lack of qualified personnel and limited practical session time persistently hinder optimal laboratory operations. The findings revealed no significant differences in perceptions across male and female teachers, indicating a shared understanding of both the strategies in place and the challenges faced. While existing strategies such as routine maintenance, safety protocols, teacher training and equipment upgrades contribute positively to practical instruction, their full potential is constrained by systemic and operational limitations. The study underscores the critical need for structured, technology-driven and policy-supported interventions, including digital inventory systems, professional development programs, preventive maintenance routines and enhanced funding mechanisms, to strengthen laboratory management and improve student engagement and skill acquisition. Overall, addressing these challenges is essential for advancing the quality, sustainability and effectiveness of technical education in Akwa Ibom State, ensuring that graduates acquire the competencies required for industrial participation, self-employment and national workforce development.

Recommendations

Based on the findings of the study, the researchers recommend that:

1. Technical Colleges in Akwa Ibom State should increase funding to ensure regular maintenance, upgrading and expansion of laboratory facilities.
2. Qualified personnel should be recruited and trained to manage laboratory resources effectively and enhance practical teaching.
3. Digital inventory and monitoring systems should be implemented to improve equipment tracking, maintenance and safety compliance.
4. Regular professional development programs should be organized for teachers to strengthen laboratory management skills and instructional effectiveness.
5. Adequate time should be allocated for practical sessions and spare parts made readily available to ensure uninterrupted laboratory-based learning.

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